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# **The impact of “incubator” organisations on opportunity recognition and technology innovation in new, entrepreneurial high-technology ventures**

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## **ABSTRACT**

The increasingly important role of small and medium-sized enterprises in both regional and national economic development has been widely acknowledged in the economic and entrepreneurship literature. The development of an economic and policy environment supporting the creation and development of new high-growth, high-technology ventures has become common strategy adopted by many policy makers as critical means of promoting future economic growth and job creation. Many of these high technology economic development programmes embrace enabling technologies such as micro and nanotechnology based firms. Although nascent entrepreneurs have numerous sources of advice and support as they embark on the venture creation pathway, aspects of an entrepreneur's past and present experience exert a central and often pivotal influence on his/her ability to engage effectively in opportunity recognition and exploitation of innovative new product technologies. This paper argues that the professional/social environment in which an entrepreneur lives and works has a fundamental impact upon his ability to recognise and exploit opportunities. The work explores the innovation process in young high technology firms and focuses upon the long-term impact of previous employment, in “incubator” organisations, in influencing opportunity recognition and product innovation processes. Findings suggests that incubator organisations fundamentally shape entrepreneurs' technical and commercial experience of markets, strongly influence their attitudes to risk and personal achievement, help develop an intricate network of social capital and resources and, finally, provide critical knowledge of the existence, availability and applicability of technology solutions in new and emerging markets. Issues are explored through in-depth interviews in 31 companies in Aberdeen, Scotland, and Ottawa, Canada, cities with established strengths in technology development in academic, commercial and government research organisations, and a history of successful high-technology firm creation. Implications for theory and policy, with particular reference to the lessons to be learned to assist the development of sectors based upon newly emerging technologies are discussed in the conclusion of the paper.

## **1. Introduction**

This paper reports on empirical findings of an investigation into how the environment, in which new, high-technology firms based on enabling technologies are created, influences the process of venture creation. It explores how the geographical region attracts and develops human capital, i.e. knowledge and experience, around which high-technology firms are created through are a variety of means such as spin-offs (Kroll and Liefner 2007), interactions (Chipika and Wilson 2006), (Pitt *et al.* 2006), (Marques *et al.* 2006), initiatives (Rasmussen *et al.* 2006), science parks (Hansson *et al.* 2005), universities (Shane and Somoya 2007) and many others. It also investigates how a region's institutions incubate entrepreneurial talent and provide a context for inter- and intra-firm level interactions which contribute significantly to technology venture creation in the short and long term (Neegaard 2005).

Understanding the importance of knowledge and experience in the innovation process, and its subsequent impact on the economic development of both firms and geographical regions, has been studied by academics in a number of knowledge domains. The economic development literature has explored the nature and impact of industrial clusters as catalysts for innovation and economic growth (Krugman 1991; Porter 1998; Storper 1997; Scott 2001) particularly by

high technology enabling technologies (Walsh and Kirchhoff 2002a, 2002b); however, the resultant large-scale, spatial effects cannot simply be explained in terms of macro-level interactions. While recent studies acknowledge the importance of continual development of knowledge and experience, they do so at a collective or regional level (Camagni 1991; Lawson and Lorenz 1997; Morgan 1997; Capello 1999; Keeble and Wilkinson 1999). Most studies do little to uncover the complex but highly important individual interactions which occur inside or between firms and institutions within a geographical space.

Entrepreneurship literature, however, usually focuses at one extreme (the individual level), usually on the founding entrepreneur or in high tech firm's entrepreneurial team. This research seeks to understand the nature and role of the entrepreneur's prior experience within the firm (Gartner 1988; Shaver and Scott 1991; Venkataraman 1997; Shane and Venkataraman 2000; Shane 2000; Alvarez and Busenitz 2001; Ardichivili *et al.* 2003; Dew *et al.* 2004; Sarason *et al.* 2006). Clearly, in high-technology ventures the entrepreneur is an important component, but is just one element in a multifaceted and complex process.

Technology innovation literature, on the other hand emphasizes firm level analysis. This literature can be bifurcated into two main themes. We categorize the first group by focusing on how firms exploit dispersed knowledge. This group seeks to combine this knowledge into groundbreaking product innovations (Hayek 1945; Utterback 1971; Tushman 1981; Nelson and Winter 1982; Dosi 1988). We define the second research thrust by those focused on better combinations of resources thereby forming the basis of a successful high-technology venture (Granstrand 1988; Newbert *et al.* 2006; Hung and Chu 2006). Most of this work, however, has been undertaken in the context of existing firms, with only a small number of studies attempting to define the combination of knowledge and experience employed in entrepreneurial, high-technology start-ups (Oakey 2003; Park 2005; Walsh *et al.* 2002).

This work explores the genesis of high-technology venture creation by studying the process at the micro level, i.e. between individuals involved in new high-technology ventures. In doing so it seeks to understand the influence and role of the geographic space within which the venture creation process takes place. Although previous research has highlighted that the local environment plays a key role in high-technology venture creation, with many technical entrepreneurs choosing to start their companies in the same geographical location as their immediate past employer (Cooper 1985; Cooper 1998; Cooper and Folta 2000), there has been little work to understand the longer-term impact of the environment in attracting and developing individuals prior to the entrepreneurial event (Harrison *et al.* 2004).

We employed qualitative case based techniques in the form of interviews conducted in 31 high-technology ventures, in two geographically distinct but complementary locations, this paper seeks to define how the environment within which these companies were created has attracted and influenced the development of the knowledge and experience of individuals.

## **2. Literature background**

### **2.1 Entrepreneurship theory revisited: the high-technology firm context**

Although recent literature has sought to define better the complex mix of technical and commercial knowledge and resources that comprise the modern high-technology firm, (Granstrand 1988; Alvarez and Busenitz 2001; Ardichivili *et al.* 2003; Oakey 2003; Park 2004) combining the classic entrepreneurship theorists Kirzner, Knight and Schumpeter provides a simple but effective picture of the knowledge challenges they face. High-technology arbitrage is an ongoing challenge to realise the market value of technical and commercial knowledge within the firm, to develop new knowledge of emerging commercial market opportunities or advances in technology and to combine this into a profitable market opportunity (Kirzner 1973). High-technology business opportunities involve a definite element of risk, so Knight's (1921) theory still holds true. To succeed the technology

entrepreneur has to make a calculated assessment that technology can be developed or acquired with the uninsurable risk it can be sold at future profit (Bell *et al.* 2004). It is, therefore, essential that the high-technology firm has access to the necessary technical and commercial knowledge to evaluate both the technical and commercial viability of the eventual product. Practical embodiment of Schumpeter's (1942) notion of creative destruction is the final part of the process, where this specialised knowledge is transformed into new technology combinations which ultimately emerge as the innovative product successes which dominate and transform markets and economies.

## **2.2 Regional clusters as new engines of knowledge creation and economic growth**

Policy makers increasingly view high-technology start-ups as being key contributors to innovation performance and economic growth (DTI 2003; OECD 2003; Scottish Executive 2001). With a significant body of academic research on regional innovation clusters and high technology agglomerations (Cooper 1970; Dorfman 1973; Oakey 1984; Hall and Markusen 1985; Saxenian 1985; Breheny and McQuaid 1987; Glasmeier 1988; Oakey and Cooper 1989; Krugman 1991; Saxenian 1994; Baptista and Swann 1998; Porter 1998), recent policy activity and significant investment have been directed towards cluster creation (OECD 2001; OECD-DATAR 2001). While there is still debate regarding the true definition of a cluster and its impact, in either innovation or economic terms (Massey *et al.* 1992; Oakey 1999), there is no doubt that the environment has a key impact upon the nature of the entrepreneurial venture (Gartner 1985; Davidsson 1995). Recent literature has expanded the role of the cluster beyond the linear model of innovation, input-output models and economies of scale, and begins to highlight the multi-level and often social nature of inter-firm knowledge exchanges within the cluster (Storper 1997). "Economic space becomes a relational space, the field of social interactions, interpersonal synergies and social collective actions that determine the innovative capability and innovative success of specific local areas" (Camagni 1997, p.1)

The concept of the innovative milieu, an innovative regional environment defining regional innovation as a series of territorial relationships (Camagni 1991), has gained much support (Morgan 1997; Lawson and Lorenz 1997; Storper 1997; Keeble and Wilkinson 1999; Malmberg and Maskell 2002). Both innovation theory and economic development are converging on an interactive model of learning and innovation involving multi-level social and institutional relationships and the importance of a shared set of local norms/values and institutions enhancing the ability to transfer knowledge from one organisation or individual to another (Malmberg and Maskell 2002). To understand the role of the region in attracting and developing human talent it is useful to define more fully key processes and mechanisms at work.

### **2.2.1 Attracting human capital**

The actual geographical environment can have an attraction effect. The pioneers of Silicon Valley were originally attracted by the physical environment (Saxenian 1994). Silicon Valley has been successful in attracting mobile firms and entrepreneurial/human capital which perceive the Valley as "the" location for high technology firms and Stanford University has also played a fundamental role in the area's development. Agencies have been stimulated to attempt to reproduce a Silicon Valley in their own backyard through establishing science parks close to universities or other institutions with a strong science/technology base (Massey *et al.* 1992; Monck *et al.* 1988). The recipe is not so simple; what occurred in California in the 1950s and 1960s can not be replicated simply where a technological university exists (Oakey 1985). The growth and survival of an industrial region may be influenced by the structures of its constituent organisations, and their relationships with their environment: "Far from being isolated from what lies outside them, firms are embedded in a social and institutional setting that shapes, and is shaped by, their strategies and structures" (Saxenian 1994). The culture of a region influences everything from the objective support environment for business creation to the perception of risk amongst actual and prospective entrepreneurs.

European cluster success stories involve similar themes. The local geography in Grenoble influenced the nature of industry by rendering mass industrialisation nigh on impossible (Druhile and Garnsey 2000). The Grenoble environment favoured the development of high value-added activity due to the local culture of innovation and strong relationships between science and industry. A similar picture emerges in Cambridge (Garnsey 1998) where the attractive living environment acts as a magnet for people choosing to locate or remain in the region (Keeble *et al.* 1999). The University of Cambridge's liberal attitude towards research collaboration also encourages a culture of knowledge transfer via spin-off companies. This environment attracts new talent into the region (Keeble 1989; Garnsey 1998; Keeble *et al.* 1999; Druhile and Garnsey 2000), one study reporting 62% of research and 67% of management staff coming into Cambridge from elsewhere in the UK.

Perhaps the best example of the attractive environments is Sophia-Antipolis (Longhi 1999). In the 1960s several large US firms (IBM and Texas Instruments) decided that the sun and sea of this traditional tourist location would provide an attractive location for a research centre. This spawned a regional development strategy to turn a tourist region into a high-technology industrial centre by attracting enterprises in research and leading-edge, global technology firms. The authorities decided to develop the infrastructure in the belief that if marketed correctly firms would come. French firms, encouraged to move by the government, arrived first followed by several large corporations which located research and development (R&D) centres or European administration bases in Sophia-Antipolis (Longhi 1999).

The extent to which a region is a magnet, however, is not purely a function of geography. A common theme in many cluster success stories is the existence locally of high-value public or private sector institutions. In Silicon Valley defence sector investment attracted a critical mass of scientific talent that would form future high-technology spin-outs (Saxennian 1994). The strategy for Sophia-Antipolis relied on public investment in infrastructure to attract large firms bringing wealth and scientific talent into the local economy (Longhi 1999). This agglomeration effect can act as a catalyst for further expansion as the reinforcing effect of building up regional assets in the form of R&D capacity attracts even more firms (Garnsey 1998; Druhile and Garnsey 2000).

### **2.2.2 Cultivating and incubating knowledge and skills**

The proposition that a certain critical mass is required to make a region self-sustaining has its origins in the Marshallian concept of industrial districts (Marshall 1947). Marshall proposed that learning between firms is enhanced when similar firms exist in close proximity as knowledge can easily be exchanged between firms. The type of knowledge has an impact on its ability to be transferred (Polyani 1966). Specialised technical knowledge is not easy to transfer; it carries a cost in learning how to decode and recode it as it is passed from one organisation to another. An organisation's ability to assimilate knowledge is also dependant upon its absorptive capacity (Cohen and Levinthal 1990), its ability to use prior knowledge and experience to effectively integrate new knowledge into the firm, and individuals play a critical role in inter-organisational knowledge transfer (Tushman and Scanlan 1981; Blackler *et al.* 2000).

Effective knowledge generation and transfer require a critical mass of activity in related technical fields. A set of co-evolving but independent units can transform a location without any deliberate coordination or planning and in some cases result in the development of a self-sustaining industrial system (Garnsey 1998). In such situations learning experiences and resources can become shared, resulting in a complex system that is almost impossible to imitate, resulting in increased regional distinctiveness and competitiveness (Storper 1997; Lawson and Lorenz 1999; Keeble and Wilkinson 1999; Keeble *et al.* 1999; Johannisson *et al.* 2002; Malmberg and Maskell 2002). Johannisson *et al.* (2002) describes institutional embeddedness as a phenomenon which builds collective entrepreneurial capabilities by

developing, producing and marketing goods, services and knowledge. The make-up and density of the institutions in the local environment can result in the development of a collective learning capacity often referred to as institutional thickness (Amin and Thrift 1995). This institutional thickness is manifested in a set of interconnected ties with firms sharing networks of economic and social exchange (Amin and Thrift 1995; Keeble *et al* 1999; Johannisson *et al.* 2002). The importance of social linkages between firms has been highlighted as a common component of regional collective learning processes (Capello 1999). Some degree of regional specialisation, institutional and social proximity enhance the quality of interaction and trust is improved with social interaction which sets in motion informal transfers of tacit knowledge (Johannisson *et al.* 2002).

The process of knowledge spill-over is a key element of modern growth theory models (Plummer and Acs 2004). Knowledge spill-overs, transfers of knowledge between firms, represent key sources of opportunities for firms and industries to improve processes or develop organisational or technological innovations (Jaffe 1986; Malmberg and Maskell 2002). Knowledge spill-over results from either the active incorporation of knowledge into the existing operations of incumbent firms or the founding of new ventures established specifically to exploit such knowledge (Plummer and Acs 2004). Due to the tacit nature of new technological knowledge it flows locally more easily than over great distances (Krugman 1991; Audretsch and Feldman 1996; Simmie 2002). Locational proximity promotes information exchange in complex and rapidly changing sectors; when technological paradigms are shifting proximity becomes ever more important as the current language becomes obsolete and the gatekeepers have to learn a new one (Dosi 1988).

### **2.2.3 *Shaping entrepreneurial intentions***

Gartner (1985) identified entrepreneurship as a multi-dimensional process with the external environment as a key component. Subsequent authors also support the proposition that a combination of personal and environmental circumstances shape individual motivation to engage in new venture creation (Naffziger *et al.* 1994; Davidsson 1995). Potential entrepreneurs are critical to a self-renewing “resilient” economic environment (Shapiro 1981) and a resilient environment requires a continual supply of individuals to take advantage of entrepreneurial opportunities. The entrepreneurial event requires a pre-existing preparedness to accept the opportunity; it also requires a precipitating or displacement event, e.g. redundancy or inheritance, to translate this preparedness into an entrepreneurial event (Naffziger *et al.* 1994; Davidsson 1995).

There is a degree of complementary overlap with the regional development literature on knowledge transfer with much academic effort invested in understanding how entrepreneurs build and maintain knowledge networks (Granovetter 1985; Chell and Baines 2000; Johannisson *et al.* 2002; Anderson and Jack 2002; Greve and Salaff 2003). The entrepreneur’s network, both business and social, plays a key role in sourcing resources and advice for the entrepreneurial venture and recent evidence suggests this is no different for the high-technology start-up (Shane and Cable 2002). Both Aberdeen and Ottawa have been the focus of recent entrepreneurship literature investigating the nature and effectiveness of networking activities of high-technology firms (MacKinnon *et al.* 2004; Madill *et al.* 2004).

A key factor in determining whether an individual will start a firm when the opportunity is presented is their perceived self-efficacy (Bandura 1986). Self-efficacy is the level of personal belief that when the entrepreneurial opportunity presents itself the nascent entrepreneur feels sufficiently competent to start a firm to realise the opportunity. Observation of others performing a task may build self-efficacy in that domain in the observer, particularly where there are similarities between the observer and the observed. This may account in part for the positive impact on new venture formation rates in localities in which entrepreneurial models are present. Researchers have tried to define the key components of entrepreneurial self-efficacy with a common theme being the importance of

developing sound commercial skills, particularly in marketing, management and financial control (Chen *et al.* 1988). In high-technology firms a balance is required between technical and managerial capabilities with some researchers exploring how academia can facilitate development of necessary general management skills (Chell and Oakey 2003; Lucas and Cooper 2004). Technical entrepreneurs are often tied closely to the technical organisations where they were employed previously, often starting a business related to their previous managerial experience, in the same geographical location (Cooper 1985; Cooper 1998; Keeble *et al.* 1999; Cooper and Folta 2000). Previous employers frequently act as incubator organisations, providing pioneering individuals with the knowledge and ideas to start their own business (Keeble 2000; Harrison *et al.* 2004). The importance of prior knowledge and experience, and its contribution to the entrepreneurial venture is also a common theme in recent opportunity recognition literature (Venkataraman 1997; Shane 2000; Shane and Venkataraman 2000; Park 2004).

The preceding discussion has identified a number of key themes central to the emergence and growth of high technology firms ranging from influences within the internal environment of the organisations within which entrepreneurial talent is incubated to those in the external environment. External factors, both physical and economic, attract human (high quality technical and entrepreneurial individuals) and organisational (firms/research infrastructure) talents and help shape the ventures which are developed. Qualitative data are presented which help to unpack some of these influences in the context of high technology venture creation and development.

### **3. A tale of two cities**

The data for this research was collected in two cities, Ottawa in Canada, and Aberdeen in the North East United Kingdom (UK), both of which are home to well-developed, technology-based clusters. The technologies are enabling since they form a basis to enter many differing market sectors (Linton and Walsh 2003). The rationale for choosing these two cities is three fold:

- i) Both cities have been the focus of academic research exploring their historical, geographic and economic development;
- ii) Both locations have a wide range of established public and private sector institutions which are potential attractors of human capital;
- iii) Both locales have a dominant industrial sector, Information and Communications Technology (ICT) in the case of Ottawa and Oil Exploration and Production in Aberdeen.

These locations, thus, represent complementary settings in which to study the genesis of entrepreneurial firms in two environments which have been well categorised and share some historical similarities in terms of cluster development.

#### **3.1 Ottawa, Canada**

Ottawa is Canada's capital and fourth largest city with a 2001 census population of 1 million. Ottawa's evolution as a technology cluster is a largely, home-grown phenomenon attributable to the start-up and growth of entrepreneurial companies over the past 30 years. Although dominated by the ICT sector with a world-class reputation for technology development, there is an emerging life sciences sector, specialising in biotechnology and biomedical devices (Wolfe 2002; Chamberlain and de la Mothe 2003) even in the face of regulatory impacts that come with biotechnology and pharmaceutical endeavours (Cooper *et al.* 2007). Sometimes labelled "Silicon Valley North" at the peak of its technology boom in 2000 Ottawa boasted more than 1,200 technology companies employing 85,000 people. The global technology downturn in 2001-2 had a significant impact on the telecommunication sector resulting in the loss of more than 20,000 jobs, as a result of redundancies at leading employers such as Alcatel, Nortel and JDS Uniphase; by 2003 technology employment totalled 64,500. However, both population and house prices have remained stable or appreciated (Chamberlin

and de la Mothe 2003). Coincident with this downturn there has actually been an increase in the number of technology companies to around 1,500 in 2003 (Ottawa Business Journal 2003) suggesting that many workers decided to start their own companies (Chamberlin and de la Mothe 2003).

Ottawa boasts a wide spectrum of world-class R&D institutions, a significant critical mass of scientists and technologists and is home to leading universities and colleges. In excess of 90% of Canada's R&D in industrial telecommunications is undertaken in the Ottawa region and it is a primary region for government spending on science and technology. Ottawa is home to many private sector technology companies, Nortel Networks, Newbridge Networks (now owned by Alcatel), Corel Corporation, JDS Uniphase, Mitel Corporation and Tundra Semiconductors. In the life sciences sector alone there are 20 Research institutes, notably the National Research Council, Ottawa Health Research Institute and the Ottawa Heart Institute.

### **3.2 Aberdeen, UK**

Aberdeen is Scotland's third largest city with a 2001 census population of 212,125. Prior to the discovery of oil in the North Sea, Aberdeen was depressed compared with the rest the UK with low wage levels and substantial outward immigration (Harris 1986). Aberdeen is now dominated by the oil industry and is widely known as the "Oil Capital of Europe". The oil industry in Aberdeen has gone through three distinct periods of growth, from its establishment in the late 1960s/early 1970s, a period of uninterrupted growth in the 1970s and 1980s, followed by recession in the mid-1980s to the current mature phase of industry development (Newlands 2000). The discovery of oil brought rapid growth to Aberdeen with the arrival of the oil giants BP and Shell who set up UK exploration and production headquarters. The related support and service companies followed soon after. In October 1971 there were 56 firms engaged in oil related activity, by October 1972 the number had increased to 109 and in October 1973 it reached 217, with two new firms arriving every week (Tiesdell and Allmendinger 2004). The arrival of oil has had a dramatic impact on the economy with around 60% of employment in the city now being oil-related (Cumbers and Martin 1997). This of course has a downside as slumps in the oil price in 1986 and 1997 led to a dramatic decrease in employment. Between 1986 and 1987 unemployment, within the region, rose by 31% with serious knock-on effects for the local economy (Newlands 2000).

The impact of the oil industry continues to have a positive effect on the local economy. The increasing challenge of developing suitable engineering and technical methods to extract oil for the aging North Sea fields has resulted in pioneering solutions developed in the North Sea finding application in wider, non-oil markets. Innovation continues with 40% of firms involved in new product development and testing (Cumbers 2000). Evidence suggests that oil-related activities are increasing in sophistication (Cumbers 2000). The oil complex also displays a healthy rate of firm foundation with over 70% of new firms established being Scottish-based. Many of these are spin-offs from larger companies managed by former managers and employees who have settled in Aberdeen, indicating a considerable incubator effect within the industry. Data also indicate that over two-thirds of firms are engaged in export activity with almost half considered as active exporters (Cumbers 2000). The main changes in the last 18 months have been asset transfers and rationalisations as the oil majors gradually withdrawing or rationalising operations in the North Sea.

There are definite proximity effects with firms developing strong links with the two local universities. Aberdeen also has one of the largest concentrations of life scientists in Europe as a result of the attractant effect of the universities and numerous internationally-renowned research institutions, e.g. the Marine Research Institute, the Rowett Research Institute and the Macaulay Land Use Research Institute.



#### 4. Methodology

The formation and growth of indigenous, entrepreneurial firms is explored by means of in-depth interviews with entrepreneurs from 31 technology firms in Ottawa (20 firms) and Aberdeen (11); firms represented differing sectors (Table 1), biotechnology (seven), software (ten), electronics (nine) and oil & gas (five), since research on contrasting sectors reveals sectoral variations in founder characteristics (Cooper 1996). Firms in Ottawa were identified via a fax survey of organisations listed in the Ottawa Business Journal Electronic Directory, while the Aberdeen sample was drawn from a number of sources. Biotechnology firms were identified via a recent directory of Scottish Biotechnology companies developed jointly between the Scottish Institute for Enterprise (SIE) and the Entrepreneurship Centre at the Massachusetts Institute of Technology. Telecommunications firms were identified through the Aberdeen branch of Business Network Scotland; and oil-related firms were all oil sector new-start recipients of government SMART awards or university spin-outs seeking to enter the Aberdeen oil-related industry.

Table 1 Survey firms by sector

<b>Sector</b>	<b>Number of firms</b>			
	<i>Ottawa</i>	<i>Aberdeen</i>	<i>Total</i>	
	<i>n %</i>	<i>n %</i>	<i>n %</i>	
Software	8 (40.0)	2 (18.1)	10	(32.3)
Electronics	8 (40.0)	1 (9.1)	9	(29.0)
Biotechnology	4 (20.0)	3 (27.3)	7	(22.6)
Oil & Gas	0 (0.0)	5 (45.5)	5	(16.1)
<b>Total</b>	<b>20 (100)</b>	<b>11 (100)</b>	<b>31</b>	<b>(100)</b>

Following Gartner (1985) and Bygrave (1988) the authors' approach was to build a comprehensive picture of the development of the firms, including the entrepreneur, the organisation, the process of firm creation and their interactions with the external environment. As the intent was to understand better the process of firm formation qualitative techniques were determined to be most appropriate (Curran and Blackburn 2001) because many soft issues, e.g. past employment history, the nature and development of social capital within the local/national environment and the complex and interactive nature of the development of the firm, are not amenable to quantification (Hammersley 1992). The objectives of the research were related to understanding process rather than measuring the contribution of key process elements (Oininas 1999). A constant comparative method was used to analyse the data gathered according to relevant research themes and triangulation in the form of company press releases, websites and other relevant documentation was used to complement the interview material (Yin 2003). A set of semi-structured interview questions was used to ensure that the critical research topics were covered but the interviewers also encouraged respondents to include additional factors or issues of importance to them and their firms.

#### 5.0 Results

The incubation and development of entrepreneurial talent are vital processes in the creation of new ventures and the emergence and exploitation of new, innovative opportunities (Totterman and Stein 2005). The knowledge, skills and expertise of founders, and others concerned with the innovation process within new and existing firms, underpin organisational competitive advantage and are developed in a range of contexts from education to employment. A region's institutions and organisations play vital roles in attracting human capital, cultivating and incubating entrepreneurial knowledge and networks and in shaping entrepreneurial intentions. Increasing evidence suggests that the ability of an entrepreneur to identify opportunities and engage in innovation and venture creation is shaped by the educational, professional and social contexts within which he studies, works and lives. Experience provides would-be entrepreneurs with a toolkit; the greater the breadth and depth of experience, the more powerful that toolkit for opportunity recognition and assessment.

Experience will affect not only his intellectual and commercial capabilities but also have a profound effect upon his ability to access resources essential for business formation and growth.

### 5.1 Attracting human capital

The majority of entrepreneurs who establish firms in technology clusters are not originally from the locality, but have been attracted by factors ranging from the quality of educational establishments, to the diversity of employment opportunities and quality of the living and working environment (Oakey *et al.* 1988, 1990; Cooper 1998). While many have lived in the locality immediately prior to start up few, typically, are born and raised there (Cooper 1998). The findings from both study locations emphasise this trend (Table 2).

Table 2 Principal founder's place of birth and place of work immediately prior to start-up of their company, relative to the location of that firm

	Ottawa		Aberdeen		Total	
Number of founders born...	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
Less than 30 miles from location of firm	2	10.5	3	27.3	5	16.7
Elsewhere	17	89.5	8	72.7	25	83.3
<b>Total</b>	<b>19*</b>	<b>100</b>	<b>11</b>	<b>100</b>	<b>30</b>	<b>100</b>
Number of founders who worked...	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
Less than 30 miles from location of firm	19	95.0	9	81.8	28	90.3
Elsewhere	1	5.0	2	18.2	3	9.7
<b>Total</b>	<b>20</b>	<b>100</b>	<b>11</b>	<b>100</b>	<b>31</b>	<b>100</b>

\* Information was unavailable for one founder who was no longer with his firm

The technology-based economies of both locations have benefited from in-migration by a large number of home and overseas nationals, attracted by opportunities to work in the regions' small and large research-intensive technology firms and national research centres and universities. This inward migration provides an important source of future, entrepreneurial talent. In the context of those who went on to establish firms, just one of 19 principal founders in Ottawa and three out of 11 principal founders in Aberdeen were born in their respective localities, while the remainder were in-migrants; of these a very small number had moved to Ottawa to attend university while most had moved to take up employment opportunities. When deciding to move to Ottawa a number of founders considered competing employment opportunities from firms in Silicon Valley in California, but selected Ottawa, in part as a result of the quality of life it offered. Many of the entrepreneurs involved in the Ottawa start-ups moved to the region for employment reasons, although it was the first permanent job for only 11 of the 20 principal founders.

Future entrepreneurs were also drawn to Ottawa by employment/research opportunities with Federal Government Agencies (including the National Research and Communications Research Centres) and the Universities of Ottawa and Carleton. A small number had moved to Ottawa to undertake undergraduate or postgraduate studies and had remained in the region following graduation. Microsystems International attracted many overseas nationals to the region to work in R&D (Manalova *et al.* 2002). Employing over 200 staff at its peak, its failure resulted in a sizeable pool of talent being released into the local job market; some former employees joined local firms while others established their own ventures. Closure of Microsystems set one founder, originally from Wales, on a career path which led to serial entrepreneurship and an influential role in a large number of the region's key technology start-ups. No fewer than nine of the entrepreneurs were attracted to work for BNR/Nortel which has acted as a magnet for high-technology employees moving into the cluster; recent

downsizing has released labour and property/office space which has been taken up by local firms. In the event of the first job not “working out” the availability of alternative, local, high quality employment opportunities reduced risks associated with long-distance relocations.

In Aberdeen engineers and chemists attracted to the oil sector had no choice but to relocate to Aberdeen as it was and still is the production hub of the UK oil industry. As a result, all of the high-technology start-ups in the oil sector were started by immigrant oil workers. In terms of public sector organisations attracting human capital, a similar picture appears in Aberdeen to Ottawa, with two out of three biotechnology start-ups initiated by individuals who were originally attracted to the region by the prestigious life sciences research profile of the University of Aberdeen. Only in the IT communications sector is there evidence of businesses started by native Aberdonians. Interestingly, two of these eventual technology entrepreneurs chose to remain in the city to pursue their academic studies as opposed to studying elsewhere in the UK, as a result of the excellent reputation of the local universities in computing sciences and the abundance of related graduate employment.

## **5.2 Cultivating and incubating knowledge and skills**

### **5.2.1 Education**

University education is a key contributor to the development and nurturing of entrepreneurial capital not only through the acquisition of knowledge in the specific domain of study but also through gaining a degree, a rite of passage to securing an increasing range of employment opportunities. In such positions individuals may develop and enhance their knowledge, skills and commercial awareness which may prove pivotal in underpinning future entrepreneurial activities. Founders of technology firms exhibit high levels of education (Monck *et al.* 1988; Cooper 1996), a factor to which Roberts (1991) attributes high rates of firm survival. Over three-quarters of founders in each of the study locations were university educated and of these approximately 80% had graduated with undergraduate or postgraduate qualifications in science and engineering disciplines. The strongly academic technical base of the biotechnology sector is attested to by the dominance of PhD-qualified founders in both Aberdeen and Ottawa.

### **5.2.2 Developing skills and experience**

Academic knowledge alone is a necessary but not, necessarily, sufficient part in the innovation jigsaw puzzle. The contribution of work experience is multifaceted, as not only does it provide founders with the opportunity to develop skills and know-how but also the chance to enhance personal/professional networks, of value in accessing resources for venture formation and development. Understanding the commercial and market contexts is essential if technology-push is not to drive the innovation process in the absence of market-pull. The old adage that “if there is no customer there is no business” is one which many entrepreneurs would do well to keep in mind, not least in the technology field, where a good idea also needs to be a great opportunity. Commercial experience plays a central role in driving home the realities of the market and providing a more objective perspective on any new innovation, be it product- or service-oriented. The ability to identify unmet needs results from being able to step into the customer’s shoes, possible only when their needs and wants are understood.

Following graduation, the majority of founders in both Ottawa and Aberdeen worked for more than one employer (Table 3); this enabled them to acquire critical skills and commercial know-how which proved invaluable when establishing their own venture. One entrepreneur commented that he realised that “the skills which [he] had used to build up that particular business [within the incubator], [he] could apply to something on the outside which would further develop [his] own career”. A small number of principal founders (six) worked for only one organisation prior to starting their own venture; however, most worked in multiple roles and/or geographical locations which enriched their knowledge and skills base and broadened their professional and social networks.

Table 3 Number of previous employers of the principal founder by location

Number of previous employers	Ottawa		Aberdeen		Total	
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
1	6	31.6	0	0.0	6	20.0
2	4	21.1	5	45.5	9	30.0
3 or more	9	47.4	6	54.5	15	50.0
<b>Total</b>	<b>19*</b>	<b>100</b>	<b>11</b>	<b>100</b>	<b>30</b>	<b>100</b>

\* Information on entire employment history not available for one principal founder.

The data in Table 3 show that no matter where the firms were started all were established by principal founders who had gained employment experience in at least one organisation prior to their entrepreneurial debut; the more specific nature of this work experience is examined below. This statistically significant finding is important in light of the fact that many entrepreneurship education programmes encourage students into early entrepreneurial activities. It, along with anecdotal evidence from interviews in both localities, emphasises the importance of actual work experience as a precursor to successful technology entrepreneurship. If young (graduates) entrepreneurs are to be successful in this sector, many will need to find some way of overcoming their lack of business/work experience, perhaps by teaming up with individuals with more experience who bring vital commercial know-how, networks and credibility to the new venture.

Early in their career founders generally had narrowly-focussed positions (influenced by their education). Many moved into more broadly-focused roles as their career developed, for example, from research/technical positions to technical sales/business development. One Ottawa founder noted that his first permanent job, a technical role with a large private-sector firm, enabled him to develop skills which proved invaluable when he found his own venture: “a greater appreciation for dealing with larger organisations ... and certainly some technical information about communications networks ... and an appreciation for manufacturing, particularly hardware manufacturing, and what it means to have lots of product out in the field and how you make changes and upgrades to it”. This experience complemented that acquired whilst working for his last employer where he developed know-how in, “the analysis of the market, understanding of how you determine various opportunities with clients and knowledge of some of the sales and distribution issues ... some of the marketing issues, in terms of launching the company...as well as some of the issues in determining the size of the available market ... skills in terms of being able to put together business plans, that was very, very well developed and [he] had quite a good system for that”.

Approximately two thirds of founders in each location (Aberdeen 64% and Ottawa 70%) worked for private sector firms immediately prior to starting their own ventures, while the rest worked in government agencies and universities. The identification of market opportunities resulted in most new ventures being established in broadly the same field of technology as the previous employer to offer different or complementary products and services, not in direct competition. The majority of firms capitalised on the knowledge and expertise of their founders so had not engaged in formal intellectual property transfer or licensing deals. Building a business in a familiar sector facilitated opportunity recognition (Timmons 1999) and reduced risks due to enhanced understanding of the commercial environment (Chandler 1996). Knowledge of customer and supplier environments was critical: “Just before I’d left Firm X, I became aware of an issue with deep water pipelines, development of oilfields in deep water. At the same time I was thinking, I knew another friend of mine who I’d known from church and he ran a small chemical company. I know about the pipeline engineering element and he knew about the gel, the pipeline people knew about the pipeline engineering

aspects but didn't know anything about the gel so I was able to bring a piece of technology for here and bring a piece of technology from there and put the two things together".

The technology which formed the basis of the ventures was often the product of combining a number of knowledge strands as found previously by Usher (1929); 11 of the 20 firms in Ottawa and nine of the 11 firms in Aberdeen were established as a result of combining complementary strands. Founders drew upon general technical knowledge acquired at university or in working for a previous employer (not just the incubator, but throughout their career with several employers). Sources ranged from universities, private sector firms and government sources to R&D carried out by the founding team. Some of those who exploited university know-how were doctoral students earlier in their careers, engaged in cutting-edge research projects; other were university staff, who licensed knowledge they developed during university-based research projects. "From academic publications, Firm X contacted me as an environmental microbiologist to work along side chemists and compare technologies. I provided using bio-analytical/biosensor techniques to provide biological assessment of contamination with Firm X providing the traditional approach of chemical assessment to compare and contrast results. We had already done extensive research with Firm X over a long period of time around five years testing and verifying technology under Firm X's budget with access to their complementary resources and all the data produced". These findings suggest how skills and know-how developed within institutions such as universities, research establishments and private sector firms influence the generation of technological know-how capable of underpinning new venture formation.

### 5.3 Shaping entrepreneurial intentions

It is one thing to identify an innovative opportunity, but quite another to seize and pursue it by establishing a new venture. Changes and ever faster-moving and shorter product life-cycles open up market opportunities which stimulate the creation of new firms (Eisenhardt and Forbes 1984). Would-be entrepreneurs respond differently to opportunities, some are attracted towards them while others take a little more persuasion to seize them. Thus, motivation plays a very important part in the genesis of new ventures (Herron and Sapienze 1992). The motivations/stimuli underpinning the entrepreneurial actions of the Ottawan and Aberdonian founders were varied (Table 4). Some were frustrated in their current employment, dissatisfied with the policies and direction of their employer. In some instances those who had worked for others felt the desire to be in control of their own destiny for a change. Some had harboured entrepreneurial ambitions for years but had been held back by a range of concerns; as one respondent put it: "I'd had an idea to set up in business for years and years and years. I'd always had an ambition to set up in business. I just didn't know quite how to do it. Also I was concerned about other risks and the issues of having family responsibilities and what to do. But I suppose as I got older I got more and more and more dissatisfied with my lot working for other people and I got to a stage where I turned 40 and I thought, if I don't do something pretty damn soon, it will be too late". Frustration combined with a sense of belief in ones own abilities to pursue the opportunity were powerful drivers for one Ottawa founder who developed a new product line for his employer; having set it up he was "basically asked to knock it down again because of a change in direction". Confident he could pursue the opportunity himself, he led a four-man team which exploited the technology with the support of local financial backers.

Table 4 Stimulus for the establishment of the firm by location

<b>Formation stimulus</b>	<b>Ottawa</b>		<b>Aberdeen</b>		<b>Total</b>	
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
Identified external opportunity*	10	50.0	5	45.5	15	48.4
Desire to work for self*	4	20.0	3	27.3	7	22.6
Previous employer not address opportunity†	3	15.0	1	9.1	4	12.9
General frustration in job†	2	10.0	0	0.0	2	6.5

Other	1	5.0	2	18.2	3	9.7
<b>Total</b>	<b>20</b>	<b>100</b>	<b>11</b>	<b>100</b>	<b>31</b>	<b>100</b>
* denotes pull factor † denotes push factor						

Other entrepreneurs were attracted by an opportunity. One software founder commented: “Initially when we first started up the idea was that I was going to go and buy and sell for other people, and with the commissions I made, get my food and drink software product developed”. Six firms were established as a result of the founder wishing to work for himself; these were all single founder ventures in which the entrepreneur enjoyed significant control over business strategy and direction. Two firms, both in biotechnology, which engaged in leading-edge research, were technology-driven, focussed on more fundamental research started within the incubator organisation. There was a sense from those who had worked in young, growing firms or held senior roles in the divisions of corporations, that time working for others provided the opportunity to adopt the role of a back seat driver, watching others at the wheel of the business, learning from experience for when they would take control of their own vehicle. Such experience built confidence in their ability to take the controls: often it took a trigger from within their employer to help them take the decision to build their own firm.

Exploitation of an opportunity requires appropriate resources. An entrepreneur’s antecedence may have a profound impact on the likelihood of him exploiting any opportunity which he recognises. Through education and work experience individuals develop key skills and enhanced knowledge; however, it is evident that successful technological exploitation increasingly requires know-how in diverse knowledge domains. Despite working in different employment roles many entrepreneurs do not have a sufficiently extensive portfolio of skills in key functional/commercial areas. In addition, some sectors require a significant commitment of finance, beyond that which any individual might be in a position to make. For these reasons, as well as to benefit from shared responsibility, risk and mutual support, the majority of high technology firms are established by entrepreneurial teams.

Time spent working with previous employers enabled would-be entrepreneurs to identify prospective business partners. The importance of entrepreneurial teams in technology venture creation (Cooper 1973; Cooper 1996; Roberts 1991; Harrison *et al.* 2004) and role of the workplace as a source of new venture partners (Harrison *et al.* 2004) are apparent in both locations. In Ottawa 75% of firms were established by entrepreneurial teams, while the figure was 77% for Aberdeen-based firms. In a large number of the team-based starts at least some founders had worked together previously, either for the same employer immediately prior to start up or earlier in their career. Familiarity, knowledge of each other’s ways of working, respective strengths and weaknesses and trustworthiness were all key benefits of such a genesis. Founders who worked in different parts of the same organisation brought distinct personal networks and contrasting experience to the start-up team. Others in start up teams were friends and neighbours drawn in through social network relations.

A lack of skills in some team members was compensated for by the strength of others to achieve the necessary blend of technical and business skills. While previous employment provided many founders with the skills to start a venture, some of those from an academic/research background lacked business experience and so relied upon partners with complementary skills and knowledge developed in a commercial environment. Interestingly, one Aberdeen-based academic biotechnology spinout struggled for over 10 years due to its lack of commercial experience and early problems with finding and incorporating the required skills into the organisation. Others with academic origins acquired external mentors, experienced in the business world, who acted as their guide, sounding board and source of wise counsel.

In addition to capitalising on professional and social networks to identify start-up team members, entrepreneurs drew on their networks to access board members and advisors as well as other important resources, such as labour and finance. While most new firms relied upon the expertise of founder(s) to launch the business many recruited additional senior staff and strengthened their board of directors with a view to long-term development of the business. In a number of cases, staff from other organisations in which the founders had worked, were recruited into senior positions and as board members. One founder recruited the same employee for a second time, having recruited him into his previous employer's business some years earlier. In other cases entrepreneurs worked with individuals earlier in their careers and, when setting up their own firm, approached them with offers of employment, in one case seven years on from when they last worked together. The dynamic employment markets in both locations meant that, often, such staff had worked for other organisations in between and brought highly developed skills and extensive networks to the new venture. While many of the firms used personal finance at start up, many recognised the need to access angel and venture capital funding for business development and growth. Links to angels and venture capitalists tended to develop as a result of entrepreneurs being involved in the complex network which has developed in the Ottawa and Aberdeen technology communities. Participation in such networks resulted from entrepreneurs living and working around their respective regions, and developing a wide social and professional network as a result. Both technology locations were described in terms of being a "small world" and "highly networked community", where those who lived and worked in the region could meet important people and use their connections to access expertise and resources.

Both Aberdeen and Ottawa are vibrant and dynamic technology communities, so founders were able to look to for inspiration to the examples of peers who had established successful technology companies within the community. Using local knowledge regarding customers, supplier and other industry actors founders built their ventures within a community where they were known players, and where they knew to whom to turn should they require assistance.

## **6.0 Conclusions**

Innovative high-technology communities are not only home to organisations at the forefront of technology development, but are also environments supportive of venture creation to exploit newly emerging opportunities. Valuable, tacit knowledge flows both within and between organisations through the movement of human capital from department to department, from organisation to organisation and from existing organisation to new venture. The attraction and subsequent intra-regional movement of those with new ideas and ways of thinking is important if a region and its organisations are to remain alert to wider opportunities and trends. Inward movement of talented individuals assists the emergence of new technologies when a community is dynamic and encourages innovation. Thinking outside the box, looking to combine knowledge from complementary and divergent domains will facilitate both the emergence and acceptance of new technological solutions.

In the context of innovation through new firm formation it is important to adopt a broad view of the entrepreneur's career to understand the gamut of influences upon him as past and present experience impacts upon opportunity recognition and exploration, and the formation and growth of any resulting venture. In the majority of cases new ventures are the product of collaborative, team endeavour rather than individual effort, often bringing together former work colleagues. Consideration of the influence of solely the immediate past employer provides too restrictive a view, as entrepreneurs often team-up with colleagues from earlier employers. A minority of founders in both locations had spun-out directly from the organisations which had attracted them to their respective; however, the majority worked for other organisations before establishing their own venture. In Ottawa, for example, names such as Mitel, Cognos and others from the region's list of technology firms appeared in the

resumes of founders. The expertise and knowledge-base which founders amassed was the product of periods of work in several of the region's organisations. Entrepreneurial learning had also occurred outside the region since some founders had worked for organisations elsewhere in Canada or overseas, while others had been transferred within their organisation to other locations, providing increased opportunities for learning. The recruitment of talent from outside a region helps to maintain a vibrant R&D environment in which immigrant talent from outside the region is embraced and their innovative approaches assimilated by the region's organisations. The movement of staff between firms at a local level facilitates the transfer of knowledge and increases the potential for boundaries of knowledge to be extended. This is particularly important for the emergence of new technological solutions as the intersection of complementary or diverse knowledge corridors may stimulate innovation and opportunity recognition.

The knowledge, skills and expertise embodied in most high-technology firms are the product of education and employment in a number of contrasting environments. Most firms are established in broadly the same sector in which founders worked previously, as founders exploit the entrepreneurial capital accumulated throughout their careers. High levels of technological, commercial and market awareness facilitate opportunity recognition and exploitation, reducing risk. This trend points to a pattern whereby the technology focus of a cluster may be intensified and perpetuated. New sectors need to fight to emerge and depend upon those who are prepared to transfer their knowledge and skills from one domain to another. The contribution of academic/public sector research environments, as homes for radical, free-thinkers outside the box, should not be downplayed, particularly in the early stages of the emergence of new technologies and the sectors which coalesce around them.

Many entrepreneurs harbour thoughts of entrepreneurship for a long time, it takes a trigger to stimulate them into action. That trigger often comes from within the incubator as it is also the setting within which the opportunity is recognised. Some ventures exploit technology not pursued by the incubator; however, more often entrepreneurs draw on know-how from a range of contexts when creating products and services to meet market needs. Founding of firms in familiar sectors, added to the tendency to establish ventures in the locality in which founders are working, leads to growth of a technological sector within a cluster. The creation of new ventures helps to maintain cluster health and dynamism; however, clusters also benefit from inward movement of its future entrepreneurs who are attracted to work in existing ventures prior to setting up their own firm, as well as talented employees on which existing and new firms depend for innovation. This movement of human capital brings vital new ideas, different perspectives and access to external networks into an agglomeration, which adds value to and enriches the environment for opportunity recognition, exploitation and the emergence of new sectors. Locations shape firms which are established within them as entrepreneurs are influenced to pursue opportunities which are evident in the locality; but they also are shaped by firms as areas gain a reputation based upon their enterprise profile which in turn shapes the types of ventures which are established.

There is a common theme amongst most of these ventures involving the interconnection of individual knowledge and knowledge networks to create complementary new knowledge combinations. It is important to reinforce a point made in the earlier discussion that this is a long-term phenomenon, occurring over a period of years and is often a complex tapestry involving knowledge connections made between individuals in multiple social and professional environments. The pervasive evidence of such phenomena in the case material provides supporting evidence of the importance of new knowledge combinations in the innovation process and the critical role of individuals in making these knowledge connections and the role of the environment in shaping their experience (Hayek 1945; Utterback 1971; Tushman 1981). It also suggests that individual knowledge corridors are not merely one-way tunnels but that they can be broadened via professional and social interaction.



This study has implications for theory relating to opportunity recognition and exploitation and for theory and policy linked to cluster development. The skills and expertise entrepreneurs develop will be influenced by all the organisations in which they have worked: the range of organisations in a locality influences the nature of the entrepreneurial nurturing ground. Many firms were local spinouts: the growing number of local role models is likely to sustain the virtuous circle of entrepreneurship. It also implies that a region's future technology orientation will be determined strongly by its current technology profile, but suggests that if the follow and interchange of people and ideas is sufficiently open and dynamic new perspectives and technological solutions will be able to find fertile soil in which to take root and develop into sustainable new sectors. Such rich and diverse technology agglomerations are likely to prove increasingly attractive to inward moving employees, some of whom will become its entrepreneurs of the future, fuelling entrepreneurial dynamism and enhancing the environment for innovation.

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